

11-15-00

11/13/00
jc945 U.S. PTO

EXPRESS MAIL LABEL NO:

EL579667052US

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jc945 U.S. PTO
09/7/23/14
11/13/00

NOVEMBER 13, 2000

Attorney Docket No.: G0026M

Box Patent Application
Assistant Commissioner for Patents
Washington, D.C. 20231

NEW PATENT APPLICATION TRANSMITTAL LETTER
(37 C.F.R. §1.53(b))

Transmitted herewith for filing is an original (nonprovisional)
patent application of:

Inventor(s): Thomas P. Glenn, Steven Webster, Markus K.
Liebhard.

Entitled: Chip Size Image Sensor Wirebond Package Fabrication
Method

Enclosed are the following papers as required for a filing date
under 37 C.F.R. §1.53(b):

0 Sheets Microfiche Appendix;
32 Pages Description;
5 Pages Claims;
1 Page Abstract; and
10 Drawing Sheets (Informal).

Other papers enclosed include:

X Return Receipt Postcard
X Check for \$ 912.00
3 Pages of Combined Declaration For Patent
Application and Power of Attorney

09/7/23/14 "11/13/00"

New Patent Application Transmittal Letter
Attorney Docket No. G0026M Page 2

2 Page(s) of Assignment of the invention to
Amkor Technology, Inc.

X Recordation Form Cover Sheet

Fee Calculation					
Claims	Number Filed	Basic Fee Allowance	Number Extra	Rate	Basic Fee
					\$710.00
Total No. of Claims	29	- 20 =	9	X \$18.00	\$ 162.00
No. Independent Claims	3	- 3 =	0	X \$80.00	\$ 0.00
Multiple Dependent Claims				\$270.00	0.00
Total of above Calculation					\$872.00
Reduction by 50% for filing by Small Entity (Enter 0.5 for small entity)					1.0
Filing Fee					\$872.00

FEE PAYMENT

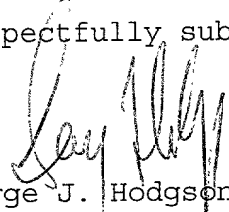
Enclosed are:

Filing Fee	\$872.00
Assignment Recording Fee	40.00
Total Fees Enclosed	\$912.00

A check in the amount of \$912.00 is enclosed

The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 50-0553.

Respectfully submitted,


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CHIP SIZE IMAGE SENSOR WIREBOND PACKAGE FABRICATION
METHOD

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5

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BACKGROUND OF THE INVENTION

Field of the Invention

10 The present invention relates generally to the packaging of electronic components. More particularly, the present invention relates to a method of forming an image sensor package.

DESCRIPTION OF THE RELATED ART

15 Image sensors are well known to those of skill in the art. An image sensor included an active area, which was responsive to electromagnetic radiation. To avoid obstructing or distorting the electromagnetic radiation which struck the active area of the image
20 sensor, it was important to avoid contamination, e.g., from dust, of the active area.

Image sensors were fabricated from a silicon wafer. More particularly, a plurality of image sensors were formed in a single silicon wafer. The silicon
25 wafer was singulated, sometimes called cut-up or diced, to separate the image sensors from one another. However, during this wafer singulation, silicon shards were generated. These silicon shards had a tendency to contaminate and scratch the active areas of the image
30 sensors. As a result, image sensors were damaged or destroyed, which undesirably decreased the yield. However, to reduce cost, it is important to have a high yield.

The singulated image sensor was then used to
35 fabricate an image sensor assembly. In this assembly,

For this reason, an important characteristic was the temperature at which condensation formed within the housing of the image sensor assembly, i.e., the dew point of the image sensor assembly. In particular, it was important to have a low dew point to insure satisfactory performance of the image sensor assembly over a broad range of temperatures.

SUMMARY OF THE INVENTION

In accordance with the present invention, an image sensor assembly, sometimes called an image sensor package, includes an image sensor having an upper surface. The image sensor further includes an active area and bond pads on the upper surface. The upper surface includes a noncritical region between the active area and the bond pads. A step up ring is mounted above the noncritical region. Electrically conductive traces on the step up ring are electrically connected to the bond pads by bond wires.

In one embodiment, a window is supported above the active area by a window support. The step up ring has a central aperture and is mounted around the window such that the window is located in or adjacent the central aperture. An inner package body, e.g., formed of an encapsulant, fills the central aperture and encloses sides of the window, thus mechanically locking the window in place.

The image sensor assembly further includes an outer package body, e.g., formed of an encapsulant. The outer package body encloses the bond pads and the bond wires. The outer package body has outer sides coplanar with sides of the image sensor. Advantageously, the image sensor assembly is the size of the image sensor, i.e., the image sensor assembly is chip size. Since the image sensor assembly is chip

size, the image sensor assembly is extremely well suited for use with miniature lightweight electronic devices, which require small and lightweight image sensor assemblies.

5 In accordance with an alternative embodiment, an image sensor assembly includes an image sensor having an upper surface. The image sensor includes an active area and a bond pad on the upper surface of the image sensor. A step up ring includes an electrically
10 conductive interior trace on a lower surface of the step up ring. The step up ring is mounted to the image sensor by an electrically conductive bump between the bond pad and the interior trace, i.e., the step up ring is flip chip mounted to the image sensor.

15 Also in accordance with present invention, a method includes mounting a window above an active area on an upper surface of an image sensor. A bond pad is on the upper surface of the image sensor and a noncritical region of the upper surface of the image
20 sensor is between the bond pad and the active area. The method further includes mounting a step up ring above the noncritical region. A trace on the step up ring is electrically connected to the bond pad, for example, with a bond wire.

25 In one embodiment, the step up ring includes a central aperture and is mounted around the window such that the window is located in or adjacent to the central aperture. The central aperture is filled with an encapsulant to form an inner package body. An outer
30 package body is formed to enclose the bond wire between the trace and the bond pad.

In another embodiment, a method includes mounting a window above an active area on an upper surface of an image sensor, the image sensor comprising a bond pad on
35 the upper surface. An interior trace on a lower

surface of a step up ring is aligned with the bond pad.
A bump is formed between the interior trace and the
bond pad to mount the step up ring to the image sensor.

In yet another alternative embodiment, windows are
5 mounted above active areas on upper surfaces of image
sensors integrally connected together as part of an
image sensor substrate. A sheet includes step up rings
integrally connected together. The sheet is aligned
with an image sensor substrate. The sheet is mounted
10 to the image sensor substrate by bumps, wherein the
windows are located in or adjacent central apertures of
the step up rings.

These and other features and advantages of the
present invention will be more readily apparent from
15 the detailed description set forth below taken in
conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a partial perspective view, partially
20 cutaway, of an image sensor assembly in accordance with
the present invention.

FIG. 2 is a cross-sectional view of the assembly
along the line II-II of FIG. 1.

FIGS. 3, 4, 5 and 6 are cross-sectional views of
25 image sensor assemblies in accordance with alternative
embodiments of the present invention.

FIGS. 7A, 7B, 7C, 7D and 7E are cross-sectional
views of structures during the fabrication of a
plurality of image sensor assemblies in accordance with
30 alternative embodiments of the present invention.

FIGS. 8A, 9, 10 and 11 are cross-sectional views
of the structure of FIG. 7A at further stages of
fabrication in accordance with the present invention.

FIG. 8B is a cross-sectional view of the structure
35 of FIG. 7B at a further stage of fabrication in

accordance with one embodiment of the present invention.

FIG. 12 is a cross-sectional view of an image sensor assembly in accordance with an alternative
5 embodiment of the present invention.

FIG. 13 is a cross-sectional view of the structure of FIG. 7A at a further stage of fabrication in accordance with another embodiment of the present invention.

FIG. 14 is a cross-sectional view of the structure of FIG. 13 at a further state of fabrication.

In the following description, the same or similar elements are labeled with the same or similar reference numbers.

15

DETAILED DESCRIPTION

An image sensor assembly 100 (FIGS. 1, 2), sometimes called an image sensor package, includes an image sensor 102 having an upper surface 102U. Image sensor 102 further includes an active area 104 and bond pads 106 on upper surface 102U. A window 110 is supported above active area 104 by a window support 108. A step up ring 120 is mounted above a noncritical region NCR of upper surface 102U of image sensor 102 between active area 104 and bond pads 106.

Electrically conductive traces 122 on step up ring 120 are electrically connected to bond pads 106 by bond wires 124. Advantageously, use of step up ring 120 allows interconnection balls 126 formed on traces 122 to have minimum size and pitch. This may be important, for example, when a large number of interconnection balls 126 must be provided in a limited area.

An inner package body 140 (FIG. 2) is formed between step up ring 120 and window support 108 and mechanically locks window 110 in place. An outer

package body 150 is formed to enclose bond wires 124,
bond pads 106, and outer sides 120S of step up ring
120. Advantageously, image sensor assembly 100 is chip
size and is extremely well-suited for use with
5 miniature lightweight electronic devices, which require
small and lightweight image sensor assemblies.

More particularly, FIG. 1 is a partial perspective
view, partially cutaway, of an image sensor assembly
100 (hereinafter assembly 100) in accordance with the
10 present invention. FIG. 2 is a cross-sectional view of
assembly 100 along the line II-II of FIG. 1. Assembly
100 is sometimes referred to as an image sensor
package.

Referring to FIGS. 1 and 2 together, assembly 100
15 includes an image sensor 102, sometimes called a sensor
device. Image sensor 102 includes an active area 104,
sometimes called an image array. Active area 104 is on
an upper, e.g., first, surface 102U of image sensor
102. Image sensor 102 further includes a lower, e.g.,
20 second, surface 102L, opposite upper surface 102U, and
sides 102S extending between upper surface 102U and
lower surface 102L.

Generally, active area 104 is responsive to
radiation, e.g., electromagnetic radiation, as is well
25 known to those of skill in the art. For example,
active area 104 is responsive to infrared radiation,
ultraviolet light, and/or visible light.
Illustratively, image sensor 102 is a CMOS image sensor
device, a charge coupled device (CCD), a pyroelectric
30 ceramic on CMOS device, or an erasable programmable
read-only memory device (EPROM) although other image
sensors are used in other embodiments.

Image sensor 102 further includes a plurality of
bond pads 106 on upper surface 102U of image sensor
35 102. Bond pads 106 are connected to the internal

interest, e.g., to the radiation to which active area 104 of image sensor 102 is responsive, as those of skill in the art will understand. In one particular embodiment, window 110 is optically transparent borosilicate glass.

Generally, the transmittance of window support 108 and window 110 is sufficient to allow the necessary minimum amount of radiation needed for the proper operation of image sensor 102 to pass through window support 108 and window 110.

During use, radiation is directed at assembly 100. This radiation passes through window 110, through window support 108 and strikes active area 104, which responds to the radiation as is well known to those of skill in the art. However, in an alternative embodiment, active area 104 of image sensor 102 transmits radiation such as electromagnetic radiation. For example, image sensor 102 is a light emitting diode (LED) micro-display. In accordance with this embodiment, radiation transmitted by active area 104 passes through window support 108, through window 110, and emanates from assembly 100. For simplicity, in the above and following discussions, active area 104 as a receiver of radiation is set forth. However, in light of this disclosure, those of skill in the art will recognize that generally active area 104 can be a receiver of radiation, a transmitter of radiation, or a transceiver, i.e., a transmitter and a receiver, of radiation. Further, in the embodiments illustrated in FIGS. 4, 5 and 6, instead of being an image sensor, sensor device 102 is a micromachine chip and active area 104 is a micromachine area containing a micromachine element.

In one embodiment, the refractive index of window support 108 is similar to the refractive index of

window 110. In this manner, the sensitivity of assembly 100 is improved compared to the prior art.

Recall that in the prior art, a housing was mounted around the image sensor and to the print
5 circuit mother board. This housing supported a window above the image sensor. However, located between the window and the image sensor was air.

Disadvantageously, air has a relatively low refractive index compared to the window. As those skilled in the
10 art understand, as visible light or other electromagnetic radiation passes from a material having a high refractive index to a material having a low refractive index and vice versa, a significant percentage of the electromagnetic radiation is
15 reflected. To illustrate, for a window having a refractive index of 1.52, at each window/air interface, approximately 4 percent of the electromagnetic radiation is reflected. Since the electromagnetic radiation had to pass from air, through the window, and
20 back through air to reach the active area of the image sensor in the prior art, a significant percentage of the electromagnetic radiation was reflected. This resulted in an overall loss of sensitivity of prior art image sensor assemblies.

25 In contrast, window 110 and window support 108 of assembly 100 have a similar refractive index. Illustratively, the difference between the refractive index of window 110 and the refractive index of window support 108 is such that the amount of radiation
30 reflected at the interface of window 110 and window support 108 is one percent or less. As an example, window 110 has a refractive index of 1.52 and window support 108 has a refractive index of 1.40. Accordingly, the amount of reflected radiation is
35 reduced compared to the prior art. This improves the

Since assembly 100 does not have a dew point, assembly 100 operates satisfactorily over a broader range of temperatures and, more particularly, at lower temperatures than image sensor assemblies of the prior art. Further, since assembly 100 is a cavityless package, there is no possibility that moisture will leak into assembly 100. Accordingly, the reliability of assembly 100 is greater than that of the prior art.

Further, the housing of a prior art image sensor assembly was typically formed of ceramic, which was relatively expensive. Advantageously, assembly 100 in accordance with the present invention eliminates the need for a housing of the prior art. Accordingly, assembly 100 is significantly less expensive to manufacture than image sensor assemblies of the prior art.

Further, since window 110 is attached directly to image sensor 102 by window support 108, image sensor assembly 100 can be made relatively thin compared to a prior art image sensor assembly. To illustrate, a 0.039 inch (1.0 mm) or less thickness for image sensor assembly 100 is easily achievable.

In contrast, the prior art image sensor housing was relatively bulky and extended upwards from the printed circuit mother board a significant distance, e.g., 0.100 inches (2.54 mm) to 0.120 inches (3.05 mm) or more. Since assembly 100 can be made relatively thin, assembly 100 is well suited for use with miniature lightweight electronic devices, which require thin and lightweight image sensor assemblies.

A step up ring 120 surrounds active area 104. Step up ring 120 is ceramic, printed circuit board material, or electrically insulative tape, e.g., epoxy laminated tape, although other electrically insulative materials can be used.

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A lower, e.g., first, surface 120L of step up ring 120 is attached directly to upper surface 102U of image sensor 102. More particularly, upper surface 102U of image sensor 102 includes a noncritical region NCR
5 between active area 104 and bond pads 106. Step up ring 120 is mounted above noncritical region NCR and, in this embodiment, lower surface 120L of step up ring 120 is directly attached to noncritical region NCR, for example, with adhesive.

10 Electrically conductive traces 122 are formed on an upper, e.g., second, surface 120U of step up ring 120. Traces 122 are electrically connected to corresponding bond pads 106 by corresponding electrically conductive bond wires 124. Electrically
15 conductive interconnection balls 126, e.g., solder, are formed on corresponding traces 122. Interconnection balls 126 are used to electrically connect assembly 100 to a larger substrate (not shown) such as a printed circuit mother board having an aperture aligned with
20 window 110.

To illustrate, a first bond pad 106A of the plurality of bond pads 106 is electrically connected to a first trace 122A of the plurality of traces 122 by a first bond wire 124A of the plurality of bond wires
25 124. A first interconnection ball 126A of the plurality of interconnection balls 126 is formed on trace 122A. In this manner, interconnection ball 126A is electrically connected to bond pad 106A. The other bond pads 106, bond wires 124, traces 122, and
30 interconnection balls 126 are electrically connected to one another in a similar fashion so are not discussed further to avoid detracting from the principals of the invention.

As set forth above, an electrically conductive
35 pathway is formed between bond pads 106 and

interconnection balls 126. However, in light of this disclosure, those of skill in the art will understand that other electrically conductive pathways can be formed. For example, contact metallizations can be
5 interposed between the various electrical conductors, e.g., between bond pads 106 and bond wires 124, between bond wires 124 and traces 122, and/or between traces 122 and interconnection balls 126. As another alternative, traces 122 extends beyond sides 120S of
10 step up ring 120 and are directly connected to bond pads 106 and bond wires 124 are not formed. As yet another alternative, interconnection balls 126 are distributed in an array format to form a ball grid array (BGA) type package. Alternatively,
15 interconnection balls 126 are not formed, e.g., to form a metal land grid array (LGA) type package or a leadless chip carrier (LCC) package. Other electrically conductive pathway modifications will be obvious to those of skill in the art.

20 By forming interconnection balls 126 on traces 122 on upper surface 120U of step up ring 120, interconnection balls 126 are elevated above exterior surface 110E of window 110.

Advantageously, use of step up ring 120 allows
25 interconnection balls 126 to have minimum size and pitch. This may be important, for example, when a large number of interconnection balls 126 must be provided in a limited area.

Step up ring 120 includes a central aperture 128.
30 Window 110 and window support 108 are located within, or are located adjacent to, central aperture 128 such that step up ring 120 is mounted around window 110 and window support 108. In one embodiment, window 110 and window support 108 are located within central aperture
35 128 and exterior surface 110E of window 110 is below

upper surface 120U of step up ring 120. In an alternative embodiment, exterior surface 110E is coplanar with upper surface 120U. In yet another embodiment, exterior surface 110E is above upper surface 120U such that window 110 protrudes from central aperture 128. Generally, exterior surface 110E of window 110 is exposed through aperture 128.

Assembly 100 further includes an inner, e.g., first, package body 140. Inner package body 140 environmentally protects, e.g., from moisture, window 110, window support 108 and active area 104. In addition, inner package body 140 provides mechanical strength to assembly 100 and, in particular, minimizes failure of window 110, window support 108 and step up ring 120.

In this embodiment, inner package body 140 fills central aperture 128 of step up ring 120 and encloses window support 108 and upper surface 102U of image sensor 102 between step up ring 120 and window support 108. Generally, inner package body 140 fills between step up ring 120 and window support 108. Further, inner package body 140, in combination with window support 108, mechanically locks window 110 in place. In particular, inner package body 140 contacts sides 110S of window 110 thus locking window 110 in place. To enhance this locking of window 110, in one embodiment, sides 110S of window 110 include a locking feature such as that discussed in Webster et al., co-pending and commonly assigned U.S. Patent Application Serial No. 09/490,717, entitled "PROTECTED IMAGE SENSOR PACKAGE", filed January 25, 2000 and Webster et al., co-pending and commonly assigned U.S. Patent Application Serial No. 09/491,112, entitled "PROTECTED IMAGE SENSOR PACKAGE FABRICATION METHOD", filed January 25, 2000, which are both herein incorporated by

of assembly 100 of FIG. 2. See also, Glenn et al., co-
pending and commonly assigned U.S. Patent Application
Serial No. 09/610,314, entitled "WAFER SCALE IMAGE
SENSOR PACKAGE", filed July 5, 2000 and Glenn et al.,
5 co-pending and commonly assigned U.S. Patent
Application Serial No. 09/610,309, entitled "WAFER
SCALE IMAGE SENSOR PACKAGE FABRICATION METHOD", filed
July 5, 2000, which are both herein incorporate by
reference in their entireties.

10 Window support 308 entirely contacts and entirely
encloses upper surface 102U including active area 104
and bond pads 106. More particularly, window support
308 has a lower, e.g., first, surface 308L in contact
with upper surface 102U of image sensor 102. Window
15 support 308 further has an upper, e.g., second, surface
308U, opposite lower surface 308L. Extending between
upper surface 308U and lower surface 308L are sides
308S of window support 308. Sides 308S are coplanar
with sides 102S of image sensor 102 and are also
20 coplanar with sides 150S of an outer package body 150A.

Interior surface 110I of window 110 is secured to
upper surface 308U of window support 308. Further, in
accordance with this embodiment, lower surface 120L of
a step up ring 120A is also secured to upper surface
25 308U of window support 308 such that step up ring 120A
is mounted above noncritical region NCR of upper
surface 102U of image sensor 102. Inner package body
140A fills the region between step up ring 120A and
window 110 and, accordingly, contacts upper surface
30 308U of window support 308 between step up ring 120A
and window 110.

As set forth above, window support 308 entirely
encloses bond pads 106. Bond wires 124 pass through
window support 308 to bond pads 106, e.g., bond wires
35 124 break through window support 308 to bond pads 106

from heat and mechanical energy during the wirebonding process. Outer package body 150A is formed on upper surface 308U of window support 308 and encloses bond wires 124.

5 FIG. 4 is a cross-sectional view of an image sensor assembly 400 (hereinafter assembly 400) in accordance with an alternative embodiment of the present invention. Assembly 400 of FIG. 4 is similar to assembly 100 of FIG. 2 and only the significant
10 differences are discussed below.

Referring now to FIG. 4, a window support 408 is formed on noncritical region NCR. More particularly, window support 408 is attached to, supported by, and contacts noncritical region NCR around active area 104
15 yet does not extend over active area 104. In this embodiment, window support 408 is an epoxy bead, e.g., a bead formed of a B-staged epoxy, which has been setup, i.e., cured, gelled, or made tacky. In one particular embodiment, window support 408 is Masterbond
20 150 manufactured by Masterbond, Inc. or Hysol 4451 manufactured by Dexter Corporation located in Industry, CA.

Window support 408 contacts a peripheral region PR of interior surface 110I of window 110. Peripheral
25 region PR of interior surface 110I is directly adjacent sides 110S and surrounds a central region CR of interior surface 110I. Window 110 and, more particularly, central region CR of interior surface 110I of window 110 overlies active area 104.

30 Window support 408 forms a seal between peripheral region PR of interior surface 110I of window 110 and noncritical region NCR of upper surface 102U of image sensor 102. Thus, window 110, window support 408, and image sensor 102 define a cavity 418, which is sealed.
35 In particular, active area 104 is located within cavity

418, which is sealed to protect active area 104 against external moisture, dust and contamination. Generally, cavity 418 contains a medium 420, which is transparent to the radiation of interest. For example, medium 420 is air.

Advantageously, the volume of cavity 418 is relatively small. By minimizing the volume of cavity 418, the amount of any moisture trapped within cavity 418 is also minimized. This, in turn, essentially eliminates the possibility of moisture condensation on interior surface 110I of window 110 or active area 104 of image sensor 102. As a result, assembly 400 has a very low or nonexistent dew point.

In this embodiment, inner package body 140 fills central aperture 128 of step up ring 120 and encloses window support 408 and upper surface 102U of image sensor 102 between step up ring 120 and window support 408, in a manner similar to that described with regards to assembly 100 of FIG. 2.

FIG. 5 is a cross-sectional view of image sensor assembly 500 (hereinafter assembly 500) in accordance with another alternative embodiment of the present invention. Assembly 500 of FIG. 5 is similar to assembly 400 of FIG. 4 and only the significant differences are discussed below.

Referring to FIG. 5, in this embodiment, a window support 508 is a rectangular, e.g., square, ring, i.e., is a rectangular block having a rectangular hole extending through the middle. An upper, e.g., first, surface 508U of window support 508 is attached to peripheral region PR of interior surface 110I of window 110, for example, with an epoxy adhesive or tape. Window 110 and window support 508 thus form an inverted cut shape enclosure.

In one embodiment, window support 508 is formed of the same material as the material of window 110, e.g., borosilicate glass. By forming window support 508 and window 110 of the same material, stress generated between window 110 and window support 508, e.g., due to differences in thermal expansion, are minimized or eliminated.

A lower, e.g., second, surface 508L of window support 508 is attached to noncritical region NCR of upper surface 102U of image sensor 102 around active area 104 by an adhesive layer 542. Illustratively, adhesive layer 542 is QMI 536 or QMI 550 manufactured by Quantum Materials located in San Diego, CA.

FIG. 6 as a cross-sectional view of an image
15 sensor assembly 600 (hereinafter assembly 600) in
accordance with yet another alternative embodiment of
the present invention. Package 600 of FIG. 6 is
similar to package 400 of FIG. 4 and only the
significant differences are discussed below.

Referring to FIG. 6, window support 608 is a rectangular, e.g., square, ring. However, in this embodiment, window support 608 and window 110 are integral, i.e., are formed of a single piece and not of a plurality of separate pieces connected together. A lower, e.g., first, surface 608L of window support 608 is attached to noncritical region NCR of upper surface 102U of image sensor 102 around active area 104 by an adhesive layer 542A.

Illustratively, window support 608 and window 110
30 are formed from a single integral sheet, e.g., of
borosilicate glass, using a method as described in
Glenn et al., co-pending and commonly assigned U.S.
Patent Application Serial No. 09/577,692, entitled
"IMAGE SENSOR PACKAGE HAVING SEALED CAVITY OVER ACTIVE
35 AREA", filed May 22, 2000, and Glenn et al., co-pending

and commonly assigned U.S. Patent Application Serial
No. 09/576,595 entitled "METHOD OF FORMING AN IMAGE
SENSOR PACKAGE HAVING SEALED CAVITY OVER ACTIVE AREA",
filed May 22, 2000, which are both herein incorporated
5 by reference in their entirety.

FIG. 7A is a cross-sectional view of a structure
700A during the fabrication of a plurality of
assemblies 100 (FIGS. 1, 2) in accordance with one
embodiment of the present invention. Structure 700A
10 includes an image sensor substrate 702 such as a
silicon wafer. Image sensor substrate 702 includes a
plurality of image sensors 102 integrally connected
together in an array format. Each of image sensors 102
are delineated by a singulation street 704, which is
15 located between adjacent image sensors 102.

As shown in FIG. 7A, windows 110 are mounted above
active areas 104 by window supports 108. For example,
a first image sensor 102A of the plurality of image
sensors 102 has a first active area 104A of the
20 plurality of active areas 104. A first window 110A of
the plurality of windows 110 is mounted above active
area 104A by a first window support 108A of the
plurality of window supports 108. The other windows
110 are similarly mounted above the other corresponding
25 active areas 104 by the other corresponding window
supports 108. Illustratively, structure 700A is
fabricated as described in Webster et al., U.S. Patent
Application Serial No. 09/491,112, cited above.

FIG. 7B is a cross-sectional view of a structure
30 700B during the fabrication of a plurality of
assemblies 300 (FIG. 3) in accordance with an
alternative embodiment of the present invention.
Structure 700B of FIG. 7B is similar to structure 700A
of FIG. 7A and only the significant differences are
35 discussed below.

In accordance with this alternative embodiment, a single window support layer 750 is formed on an upper, e.g., first, surface 702U of image sensor substrate 702. Windows 110 are mounted above active areas 104 by window support layer 750, illustratively, as described in Glenn et al., U.S. Patent Application Serial No. 09/610,309, cited above. For example, window 110A is mounted above active area 104A by window support layer 750.

FIGS. 7C, 7D and 7E are cross-sectional views of structures 700C, 700D, 700E during the fabrication of a plurality of assemblies 400, 500, 600 (FIGS. 4, 5, 6), respectively, in accordance with alternative embodiments of the present invention. Structures 700C, 700D, 700E of FIGS. 7C, 7D and 7E are similar to structure 700A of FIG. 7A and only the significant differences are discussed below.

Referring now to FIG. 7C, windows 110 are mounted above active areas 104 by window supports 408. To illustrate, window 110A is mounted above active area 104A by a first window support 408A of the plurality of window supports 408.

Referring now to FIGS. 7D, 7E, windows 110 are mounted above active areas 104 by window supports 508, 608 and adhesive layers 542, 542A, respectively. To illustrate, referring to FIG. 7D, window 110A is mounted above active area 104A by a first window support 508A of the plurality of window supports 508 and by a first adhesive layer 542-1 of the plurality of adhesive layers 542. Similarly, referring to FIG. 7E, window 110A is mounted above active area 104A by a first window support 608A of the plurality of window supports 608 and by a first adhesive layer 542-1A of the plurality of adhesive layers 542A. Illustratively, structures 700C, 700D, 700E are fabricated as described

in Glenn et al., U.S. Patent Application Serial No. 09/576,595, cited above.

FIG. 8A is a cross-sectional view of structure 700A of FIG. 7A at a further state of fabrication.

5 Referring to FIG. 8A, step up rings 120 are mounted above upper surface 702U of image sensor substrate 702, for example with adhesive. Stated another way, lower surfaces 120L of step up rings 120 are mounted above noncritical regions NCR on upper surfaces 102U of image
10 sensors 102. More particularly, lower surfaces 120L of step up rings 120 are mounted directly to noncritical regions NCR on upper surfaces 102U of image sensors 102. Step up rings 120 are mounted around window supports 108 and windows 110 such that window supports
15 108 and windows 110 are located in or adjacent central apertures 128 of step up rings 120.

To illustrate, a lower surface 120L of a first step ring 120-1 of the plurality of step up rings 120 is directly mounted to noncritical region NCR on upper
20 surface 102U of image sensor 102A. Step up ring 120-1 is mounted around window 110A and window support 108A such that window support 108A and window 110A are located in or adjacent central aperture 128 of step up ring 120-1. The other step up rings 120 are mounted
25 above the other corresponding noncritical regions NCR on upper surfaces 102U of image sensors 102 in a similar manner.

In one embodiment, step up rings 120 are individual pieces, which are mounted one at a time,
30 i.e., sequentially. In another embodiment, step up rings 120 are individual pieces, which are all mounted at the same time, i.e., simultaneously.

In yet another embodiment, a single sheet 804, e.g., of epoxy laminated tape, includes a plurality of
35 step up rings 120 integrally connected to one another,

128 of step up ring 120-1A. The other step up rings 120A are mounted above the other corresponding noncritical regions NCR on upper surfaces 102U of image sensors 102 in a similar manner.

5 FIGS. 9, 10, and 11 illustrate the fabrication of a plurality of assemblies 100 (FIGS. 1, 2). However, it is understood that a plurality of assemblies 300, 400, 500, 600 (FIGS. 3, 4, 5, 6, respectively) are fabricated in a similar manner as that illustrated in
10 FIGS. 9, 10, and 11 and so fabrication of assemblies 300, 400, 500, 600 is not discussed further to avoid attracting from the principals of the invention.

FIG. 9 is a cross-sectional view of structure 700A of FIG. 8A at a further stage of fabrication.

15 Referring to FIG. 9, traces 122 on upper surfaces 120U of step up rings 120 are electrically connected to bond pads 106 of image sensors 102 by bond wires 124.

FIG. 10 is a cross-sectional view of structure 700A of FIG. 9 at a further stage of fabrication.
20 Referring to FIG. 10, inner package bodies 140 are formed. To illustrate, a first inner package body 140-1 of the plurality of inner package bodies 140 is formed by encapsulant filling between step up ring 120-1 and window support 108A/window 110A. More generally,
25 central aperture 128 of step up ring 120-1 is filled with encapsulant to form inner package body 140-1. For example, central aperture 128 is filled with a liquid encapsulant, which is cured to form inner package body 140-1. Alternatively, central aperture 128 is filled
30 with a plastic encapsulant to form inner package body 140-1. The other inner package bodies 140 are formed in a similar manner simultaneously, or alternatively, sequentially.

Referring still to FIG. 10, outer package bodies
35 150 are formed. Outer package bodies 150 are formed by

encapsulant filling between step up rings 120. For example, the regions between step up rings 120 are filled with a liquid encapsulant, which is cured to form outer package bodies 150. Alternatively, the regions between step up rings 120 are filled with a plastic encapsulant to form outer package bodies 150.

After formation of package bodies 150, in one embodiment, a lower, e.g., second surface 702L of image sensor substrate 702 is back lapped, i.e., ground down. Back lapping lower surface 702L reduces the thickness of image sensor substrate 702 and, correspondingly, results in a minimum thickness for assembly 100 (FIG. 2).

FIG. 11 is a cross-sectional view of structure 700A of FIG. 10 at a further stage of fabrication. Referring now to FIG. 11, interconnection balls 126 are formed on traces 122. In one embodiment, after formation of interconnection balls 126, each assembly 100 is tested for validity, i.e., to determine whether the assembly 100 is defective or not. Advantageously, testing each assembly 100 while still in wafer form, i.e., before singulation of image sensor substrate 702, is less labor intensive and less complex than testing each assembly 100 individually.

After formation of interconnection balls 126 and, optionally, validity testing assemblies 100, image sensor substrate 702 is singulated along singulation streets 704 resulting in a plurality of assemblies 100 (FIGS. 1, 2). Alternatively, interconnection balls 126 are formed on traces 122 after image sensor substrate 702 is singulated. Although the formation of a plurality of assemblies 100 simultaneously is described above, it is understood that assemblies 100 can be fabricated on an individual basis, if desired.

FIG. 12 is a cross-sectional view of an image sensor assembly 1200 (hereinafter assembly 1200) in accordance with an alternative embodiment of the present invention. Assembly 1200 of FIG. 12 is similar to assembly 100 of FIG. 2 and only the significant differences are discussed below.

Referring now to FIG. 12, a step up ring 120B is flip chip mounted to image sensor 102. More particularly, formed on lower surface 120L of step up ring 120B are a plurality of electrically conductive interior, e.g., first, traces 1214, which include a first interior trace 1214A. Bond pads 106 are electrically connected to corresponding interior traces 1214 by corresponding electrically conductive bumps 1212, sometimes called flip chip bumps 1212. Illustratively, bumps 1212 are: (1) stud bumps, i.e., gold balls; (2) electrically conductive epoxy paste; (3) electrically conductive epoxy film; or (4) solder. Generally, step up ring 120B is mounted to image sensor 102 by bumps 1212.

Traces 122, sometimes called exterior or second traces 122, on upper surface 120U of step up ring 120B are electrically connected to corresponding interior traces 1214 by corresponding electrically conductive vias 1218. Vias 1218 extend through step up ring 120B from lower surface 120L to upper surface 120U.

To illustrate, bond pad 106A is electrically and physically connected to interior trace 1214A by a first bump 1212A of the plurality of bumps 1212. Interior trace 1214A is electrically connected to trace 122A by a first via 1218A of the plurality of vias 1218. Formed on trace 122A is interconnection ball 126A.

Advantageously, step up ring 120B is readily flip chip mounted to image sensor 102, which can have a wide variety of arrangements of bond pads 106.

Illustratively, bond pads 106 are arranged in rows adjacent sides 102S of image sensor 102 (see FIG. 1, for example). Alternatively, bond pads 106 are distributed, e.g., in an array, on upper surface 102U of image sensor 102.

Referring still to FIG. 12, a package body 1240 fills central aperture 128 of step up ring 120B and encloses window support 108. Package body 1240 is formed of any one of a number of underfill materials commonly used in flip chip processing.

In this embodiment, due to the flip chip mounting of step up ring 120B, a space exists between lower surface 120L of step up ring 120B and upper surface 102U of image sensor 102. Package body 1240 fills this space between lower surface 120L of step up ring 120B and upper surface 102U of image sensor 102. Package body 1240 extends to sides 102S of image sensor 102 such that sides 120S of step up ring 120B, sides 1240S of package body 1240 and sides 102S of image sensor 102 are coplanar.

As shown in FIG. 12, package body 1240 also encloses bumps 1212. Package body 1240 enhances the reliability of assembly 1200 by preventing the failure of bumps 1212 and preventing the associated dismounting of step up ring 120B. For example, package body 1240 insures that step up ring 120B does not become dismounted from image sensor 102 as a result of any differential thermal extension between step up ring 120B and image sensor 102.

In FIG. 12, window 110 is mounted to image sensor 102 by window support 108. However, in alternative embodiments, instead of using window support 108 to mount window 110, window support 308, 408, 508, or 608 of FIG. 3, 4, 5, or 6, respectively, is used to mount window 110 to image sensor 102.

FIG. 13 is a cross-sectional view of structure 700A of FIG. 7A at a later stage during fabrication of a plurality of assemblies 1200 (FIG. 12) in accordance with one embodiment of the present invention. A single
5 sheet 1310 comprises a plurality of step up rings 120B integrally connected together. Sheet 1310 is mounted to image sensor substrate 702 by bumps 1212.

To form bumps 1212 and thus mount sheet 1310, sheet 1310 is aligned with image sensor substrate 702
10 using any one of a number of alignment techniques, e.g., sheet 1310 is optically or mechanically aligned. More particularly, interior traces 1214 on lower surfaces 120L of step up rings 120B are aligned with corresponding bond pads 106. Bumps 1212 are formed
15 between interior traces 1214 and bond pads 106 thus mounting sheet 1310 to image sensor substrate 702 and, more specifically, mounting step up rings 120B to corresponding image sensors 102.

To illustrate, a first interior trace 1214A is
20 formed on lower surface 120L of a first step up ring 120-1B of the plurality of step up rings 120B. Interior trace 1214A is aligned with bond pad 106A. Bump 1212A is formed between interior trace 1214A and bond pad 106A. Bump 1212A physically and electrically
25 connects interior trace 1214A to bond pad 106A thus flip chip mounting step up ring 120-1B to image sensor 102A. The other step up ring 120B are flip chip mounted to the other image sensors 102 in a similar manner.

30 Bumps 1212 are formed using any one of a number of techniques. For example, solder bumps are formed on bond pads 106 of image sensors 102 or on interior traces 1214, and these solder bumps are reflowed to form bumps 1212. Alternatively, bumps 1212 are formed
35 by applying an electrically conductive epoxy paste or

film to bond pads 106 or interior traces 1214 and thermally or optically curing this electrically conductive epoxy paste or film. As a further alternative, bumps 1212 are formed by thermal or
5 thermosonic bonding of gold bumps formed on bond pads 106 or on interior traces 1214. In light of this disclosure, those of skill in the art will understand that other methods of attaching sheet 1310 to image sensor substrate 702 can be used.

10 Advantageously, bumps 1212 are formed simultaneously reducing labor and increasing efficiency compared to wirebonding each bond pad 106 sequentially. In this manner, the cost of fabricating assembly 1200 (FIG. 12) is minimized.

15 FIG. 14 is a cross-sectional view of structure 700A of FIG. 13 at a further stage of fabrication. As shown in FIG. 14, package bodies 1240 are formed to enclose window supports 108, bumps 1212 and generally to fill the space between sheet 1310 and image sensor
20 substrate 702. To illustrate, a first package body 1240A of the plurality of package bodies 1240 is formed by underfilling between step up ring 120-1B and image sensor 102A and around window support 108A/window 110A.

To avoid trapping air underneath sheet 1310, in
25 one embodiment, an underfill material is applied into a central aperture 128 of a first step up ring 120B of sheet 1310 and allowed to flow between sheet 1310 and image sensor substrate 702 to the adjacent central apertures 128 of the adjacent step up rings 120B of
30 sheet 1310. This allows the air in the space between sheet 1310 and image sensor substrate 702 to be displaced, instead of trapped, by the underfill material.

To illustrate, underfill material is applied into
35 a central aperture 128 of step up ring 120-1B around

CLAIMS

WE CLAIM:

1. A method comprising:

5 mounting a window above an active area on a first surface of a sensor device, said sensor device comprising a bond pad on said first surface;
mounting a step up ring above a noncritical region of said first surface between said bond pad and said active area; and
10 electrically connecting a trace on said step up ring to said bond pad.

2. The method of Claim 1 wherein said mounting a step up ring comprises directly mounting a first
15 surface of said step up ring to said noncritical region.

3. The method of Claim 1 wherein said step up ring is mounted around said window.
20

4. The method of Claim 3 wherein said step up ring comprises a central aperture, said window being located in or adjacent said central aperture.

25 5. The method of Claim 1 wherein said sensor device is one of a plurality of sensor devices integrally connected together in a wafer.

30 6. The method of Claim 5 wherein said step up ring is one of plurality of step up rings integrally connected together in a sheet, said method further comprising mounting a first surface of said sheet to a first surface of said wafer.

35 7. The method of Claim 6 further comprising

16. The method of Claim 15 wherein said active area is responsive to radiation.

5 17. A method comprising:
mounting a window above an active area on a first surface of a sensor device; and
directly attaching a first surface of a step up ring to said first surface of said sensor device, said
10 step up ring being mounted around said window.

18. The method of Claim 17 wherein said directly attaching comprises directly attaching said first surface of said step up ring to said first surface of
15 said sensor device with adhesive.

19. The method of Claim 17 wherein said sensor device comprises a bond pad on said first surface of said sensor device, a noncritical region of said first surface of said sensor device being between said active area and said bond pad, said directly attaching
20 comprises directly attaching said first surface of said step up ring to said noncritical region.

20. The method of Claim 19 further comprising electrically connecting said bond pad to an electrically conductive trace on a second surface of said step up ring.

21. The method of Claim 20 wherein said electrically connecting comprises forming a bond wire between said bond pad and said trace.

22. The method of Claim 20 further comprising
35 forming an interconnection ball on said trace.

CHIP SIZE IMAGE SENSOR WIREBOND PACKAGE FABRICATION
METHOD

Thomas P. Glenn

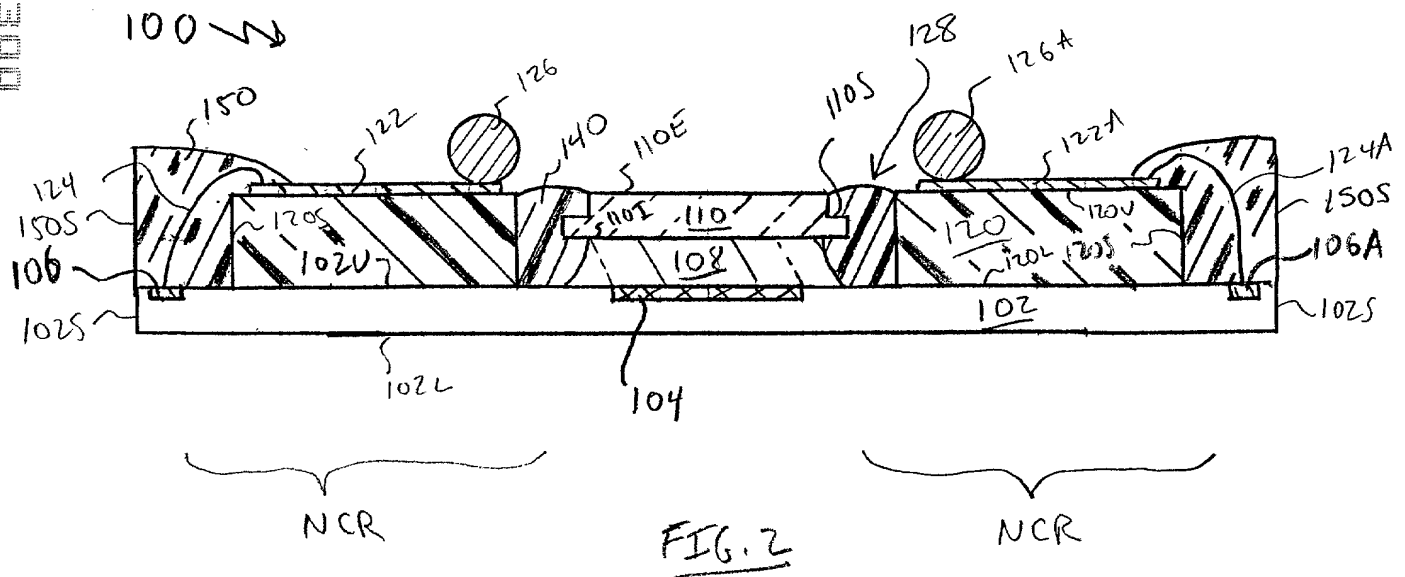
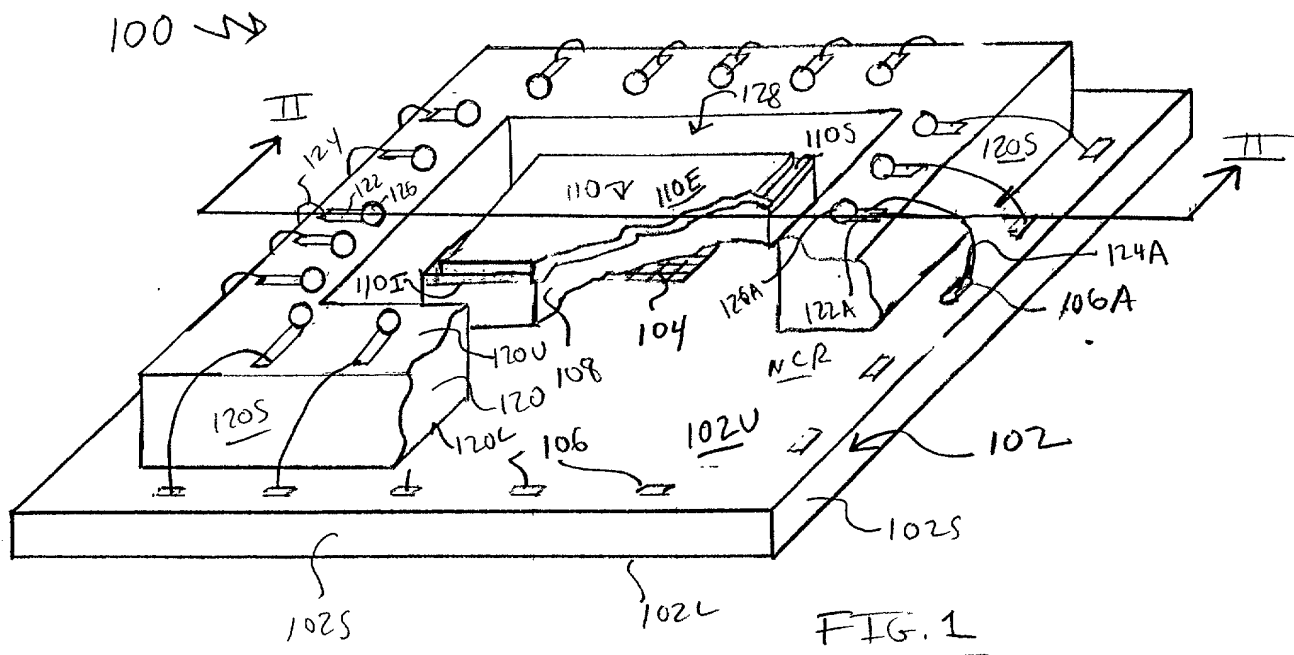
Steven Webster

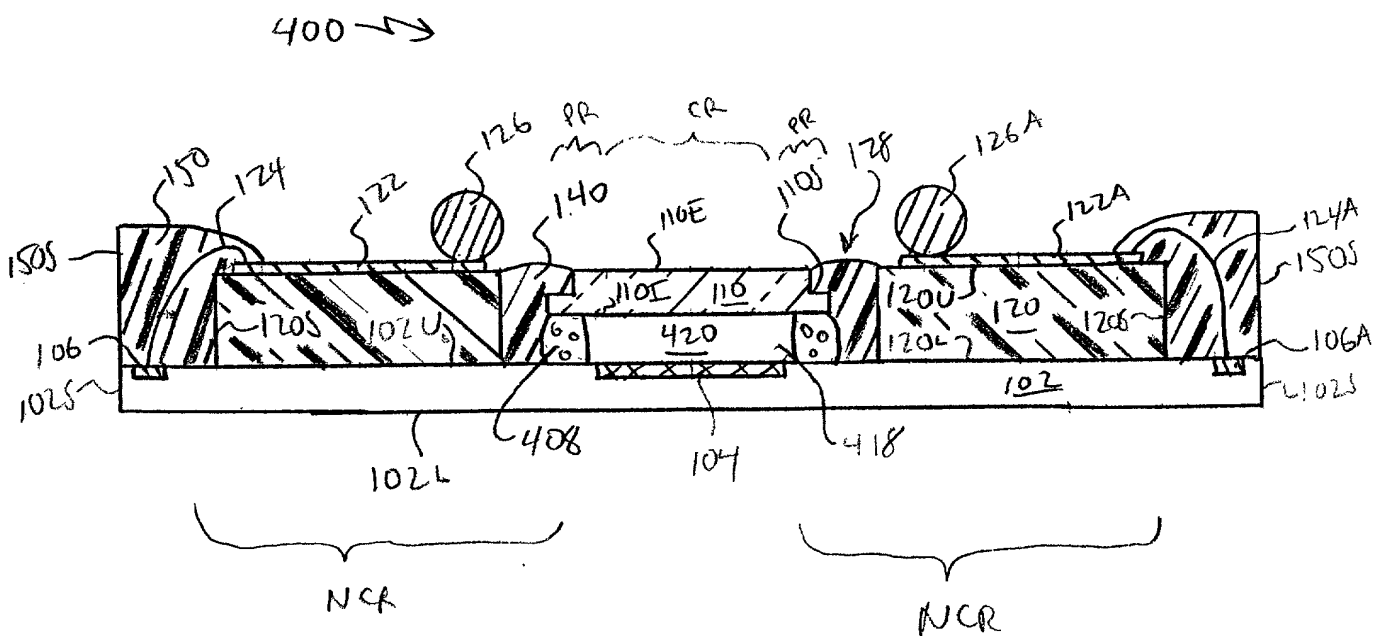
Markus K. Liebhard

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ABSTRACT

To form an image sensor package, a window is mounted above an active area on an upper surface of an image sensor. A noncritical region of the upper surface of the image sensor is between the active area and bond pads of the image sensor. A lower surface of a step up ring is mounted above the noncritical region of the upper surface of the image sensor. An upper surface of the step up ring includes a plurality of electrically conductive traces. Bond wires are formed between the bond pads of the image sensor and the electrically conductive traces on the upper surface of the step up ring. The step up ring is mounted so that the window is located in or adjacent a central aperture of the step up ring. The central aperture of the step up ring is filled with an encapsulant to form an inner package body. An outer package body is formed by enclosing the bond pads and bond wires in an encapsulant.





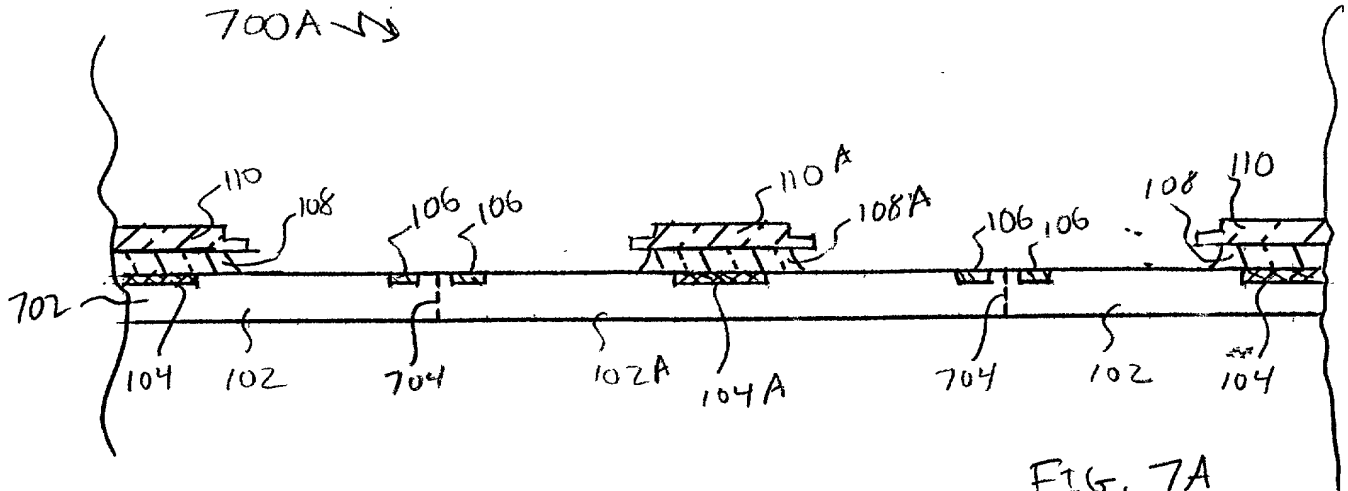
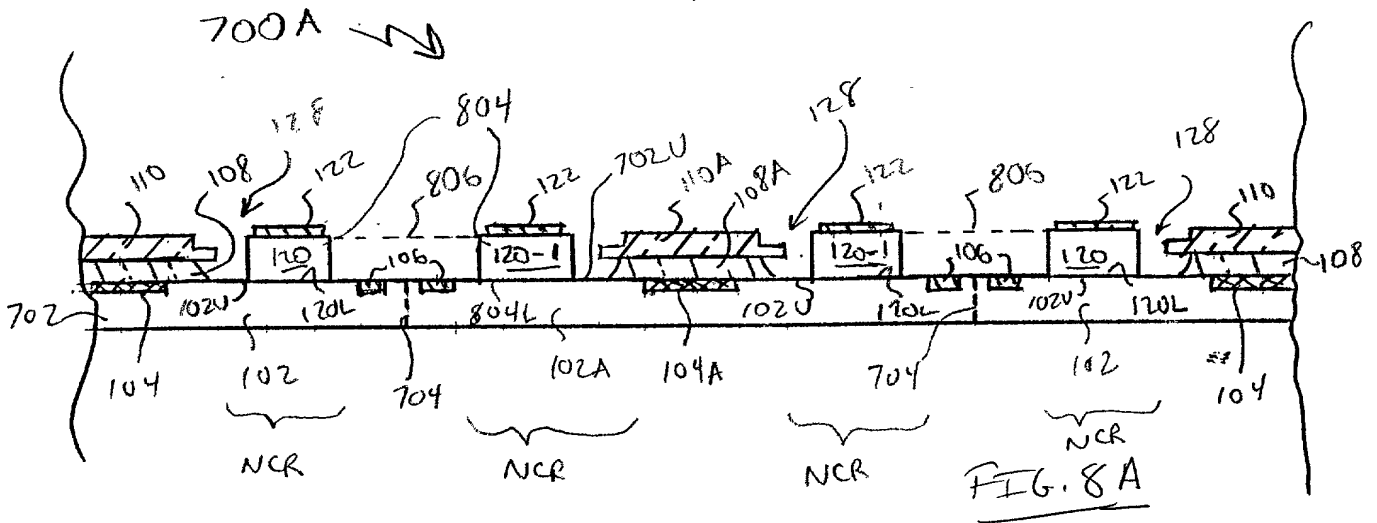


Fig. 7A



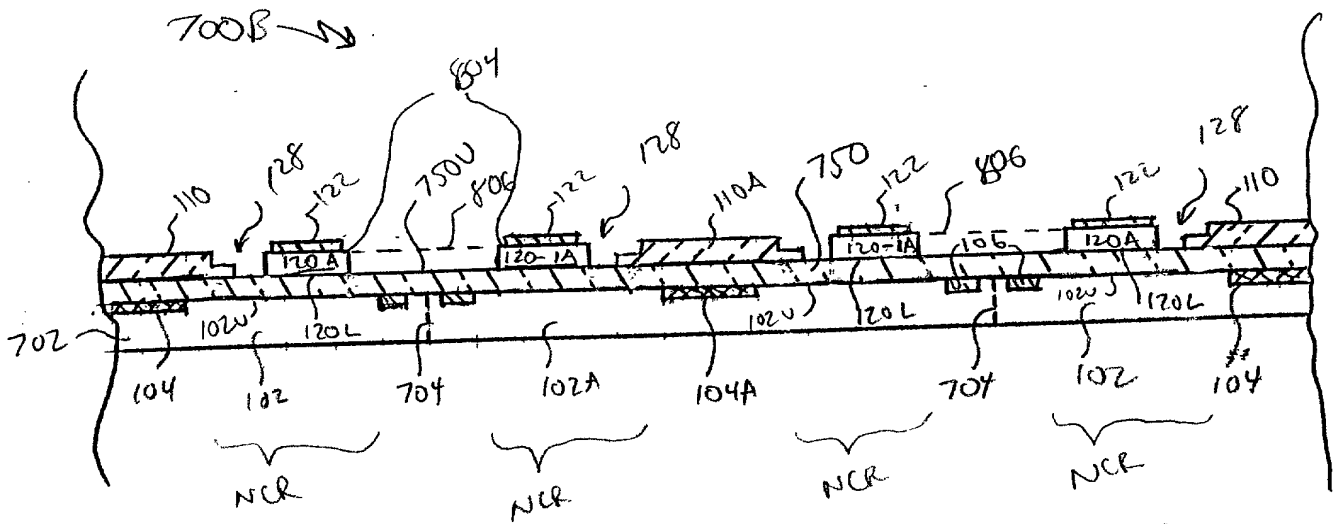
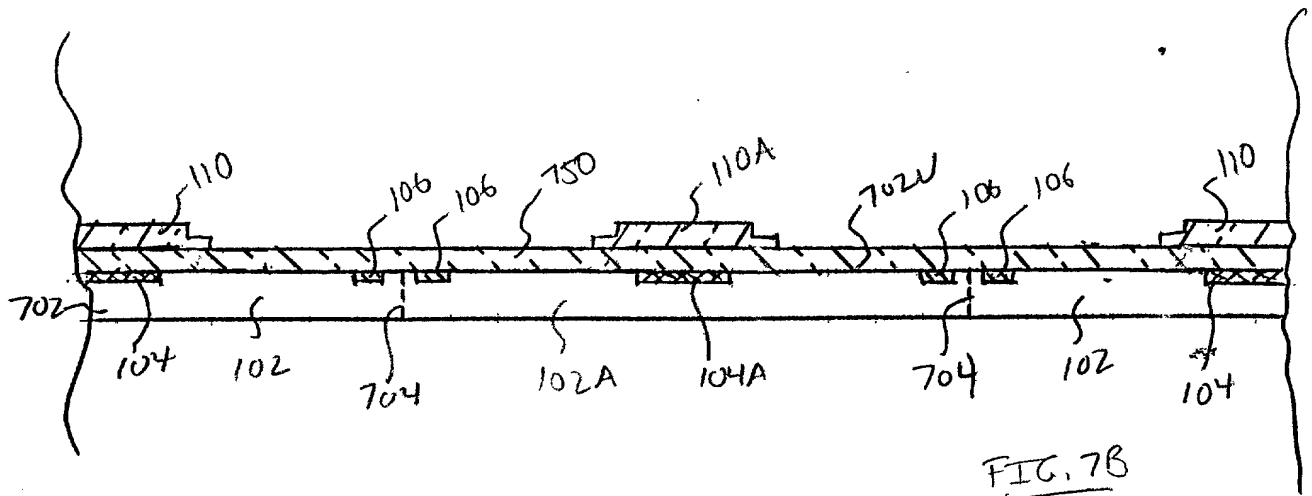
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FIG. 8B

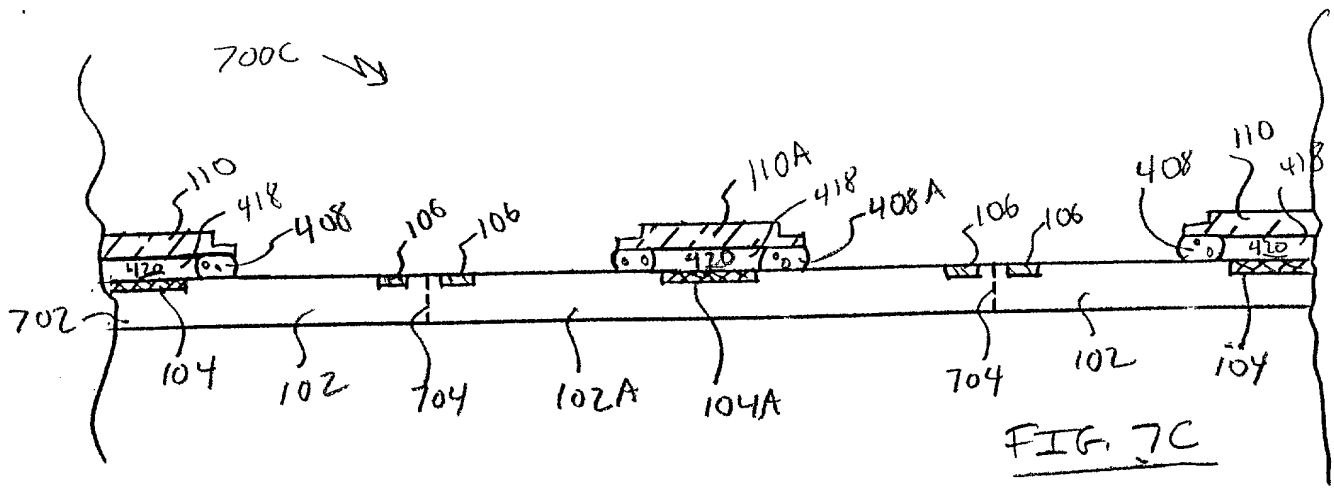


FIG. 7C

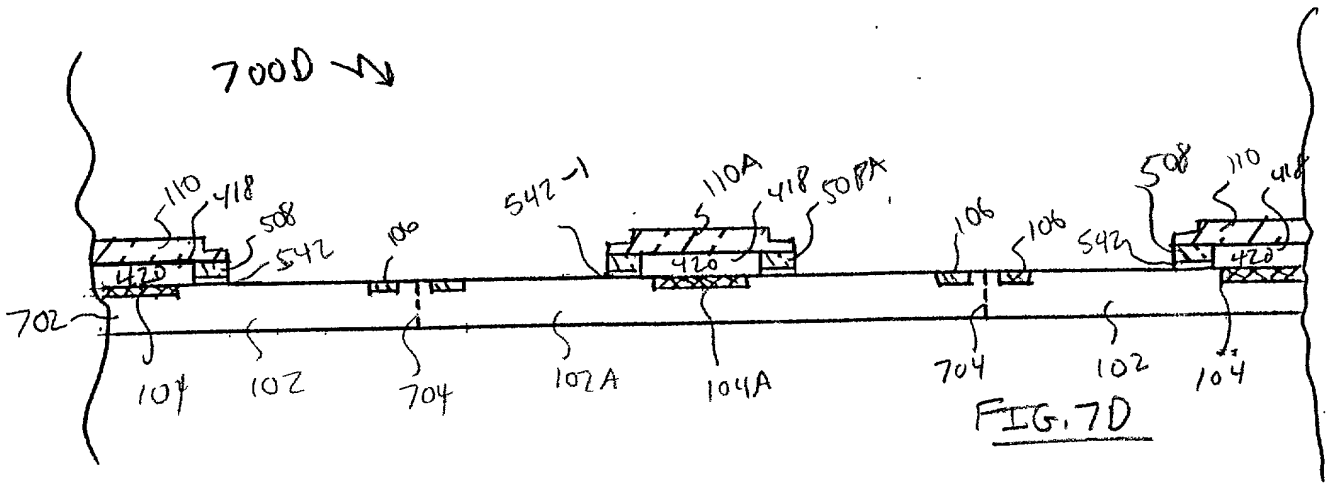


FIG. 7D

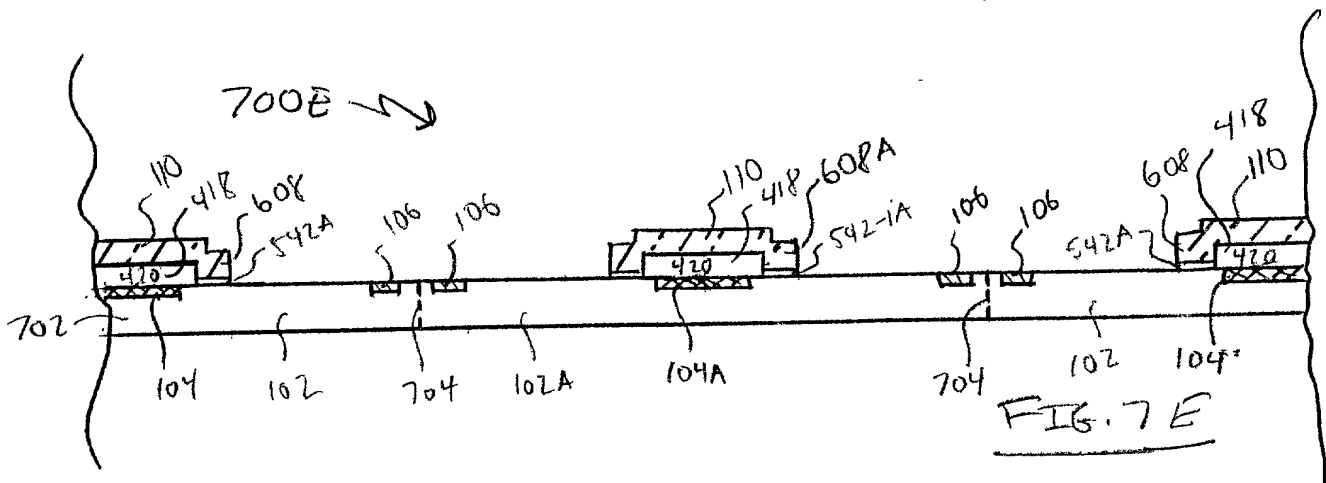


FIG. 7E

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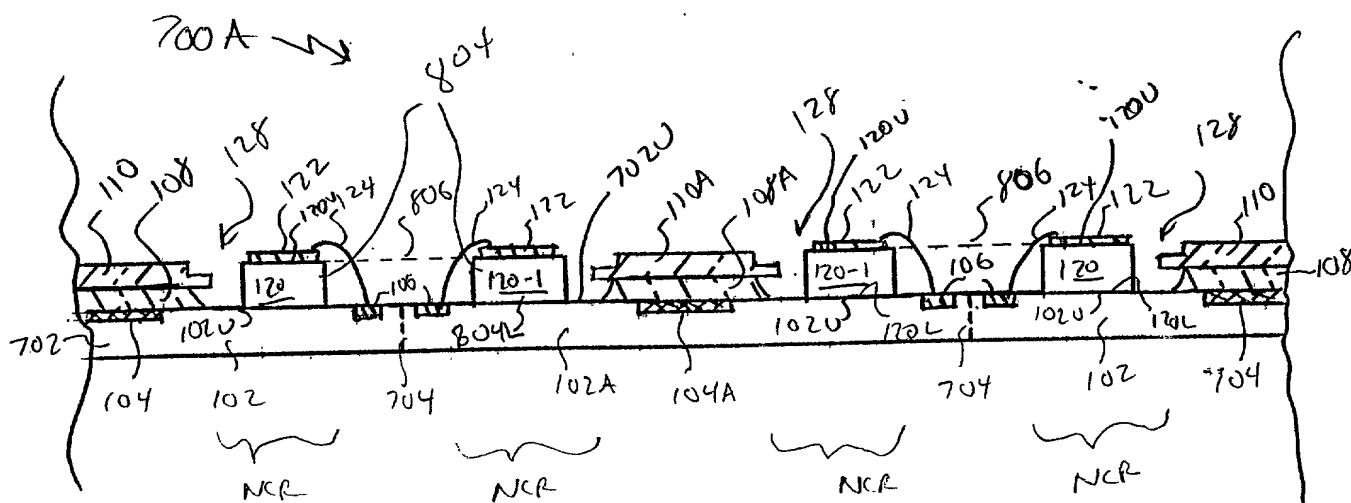
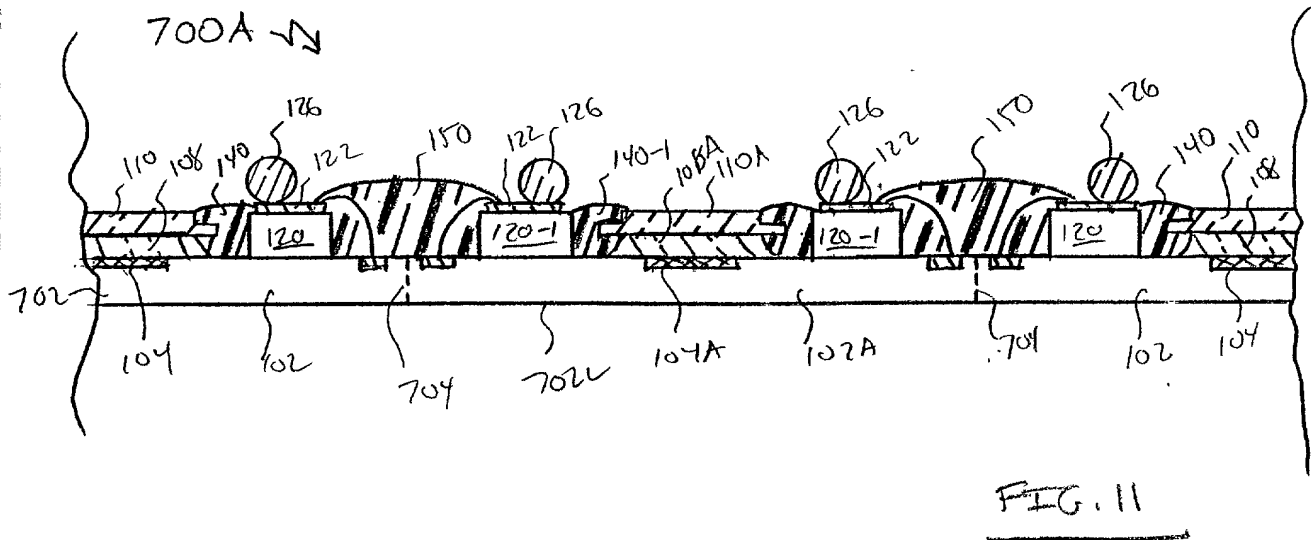
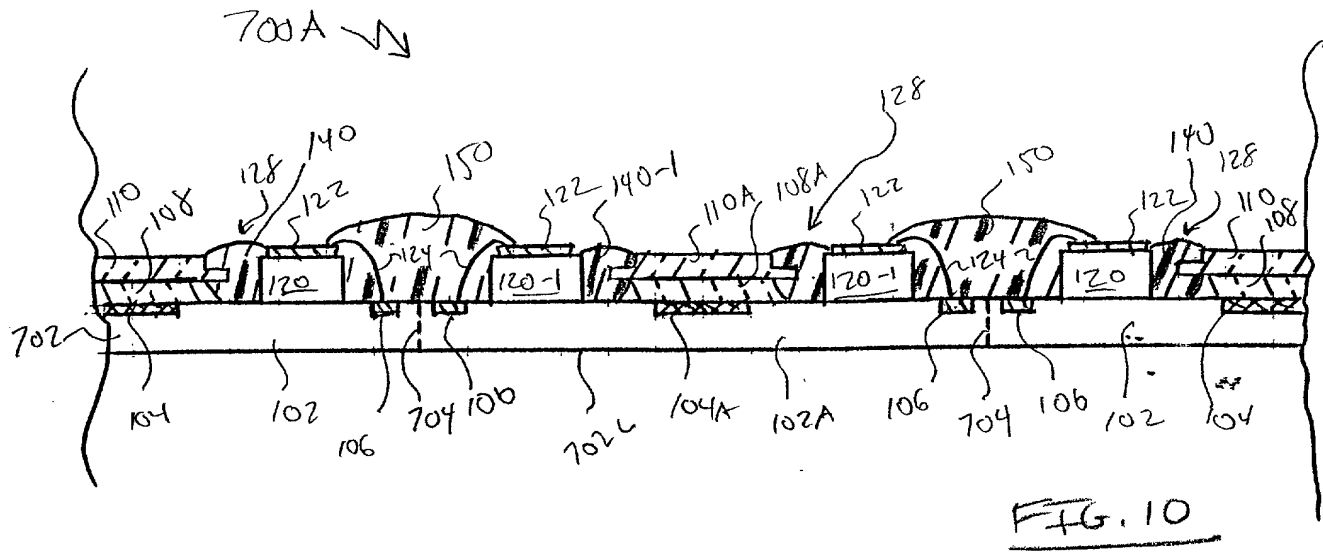


FIG. 9



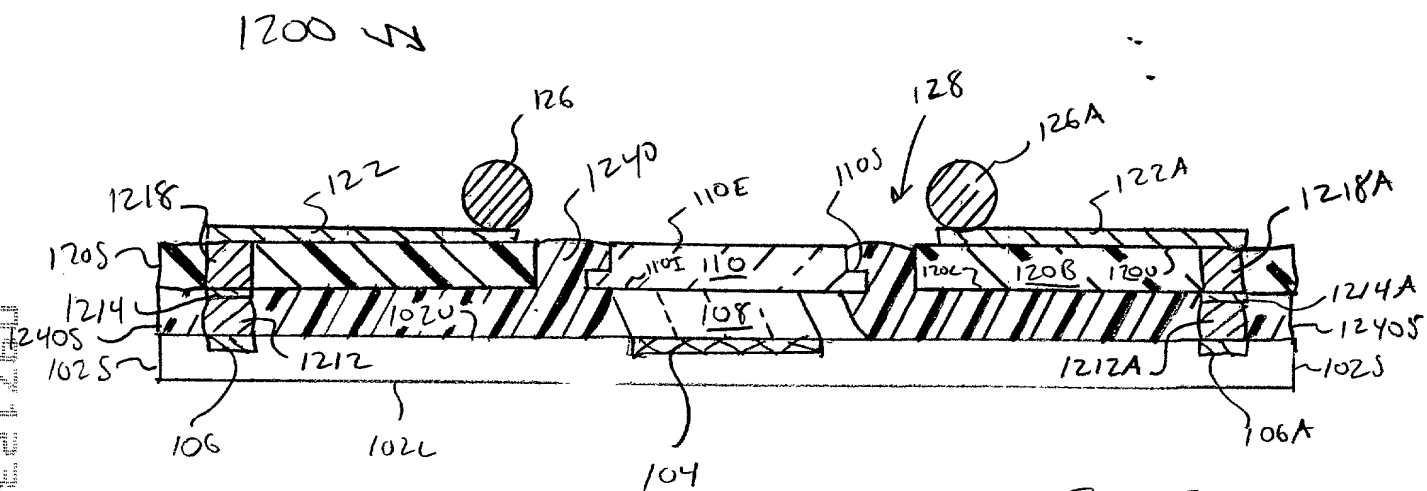


FIG. 12

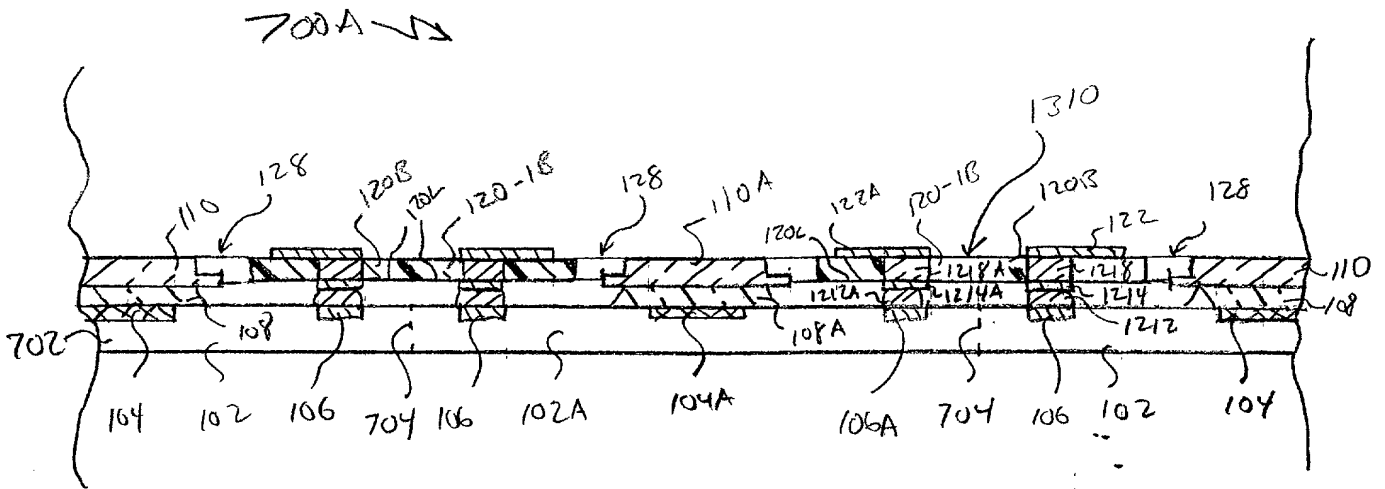


FIG. 13

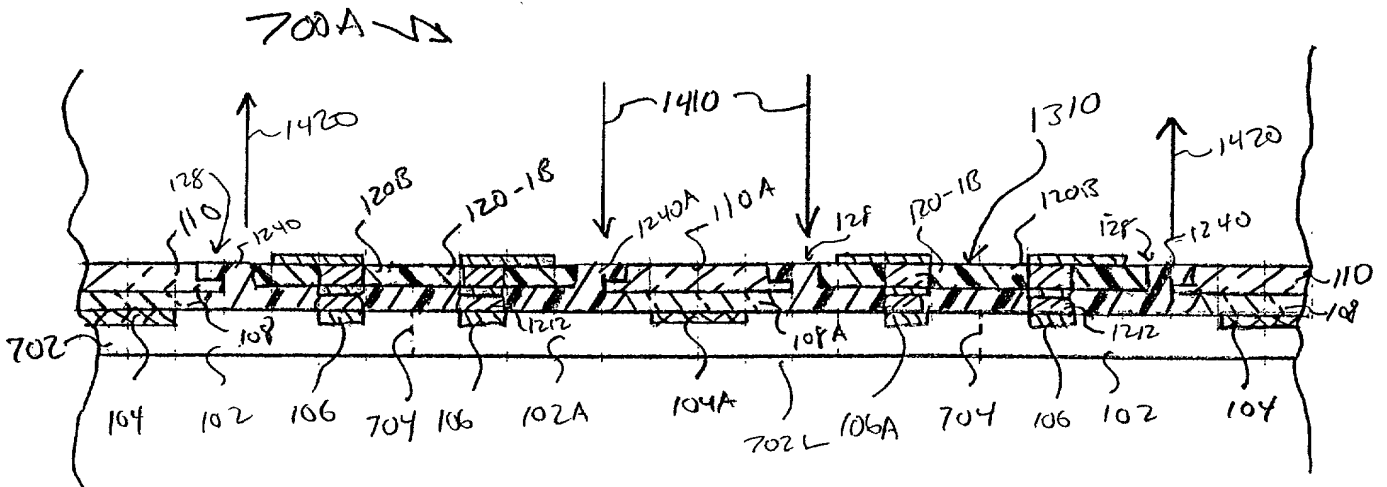


FIG. 14

NA		
(Application Serial No.)	(Filing Date)	(Status-patented, pending, abandoned)
NA		
(Application Serial No.)	(Filing Date)	(Status-patented, pending, abandoned)
NA		
(Application Serial No.)	(Filing Date)	(Status-patented, pending, abandoned)

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Title 18, United States Code, § 1001 and that such willful false statements may jeopardize the validity of the application or ~~any patent~~ issued thereon.

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